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Bi-dimensional position sensor of magnetic type, particularly for motor vehicle applications

Abstract:

The bi-dimensional position sensor (1) can be advantageously used in the turn system controlled from the steering wheel of a vehicle and comprises a permanent magnet (3) fixed to a control lever (4) so as to move in a plane along a first (X) and a second (Y) direction and rotate about a third direction (W) orthogonal to the preceding ones. The permanent magnet is movable with respect to an integrated device comprising a first group of sensor elements (101-103) arranged spaced along the first direction, a second group of sensor elements (104-107) arranged spaced along the second direction and a third group of sensor elements (108-109) detecting the angular position of the permanent magnet. Electronics integrated with the sensor elements generate a code associated with each position which the permanent magnet (3) may assume and a control signal (S) corresponding to the desired function.

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(54) Bi-dimensional position sensor of magnetic type, particularly for motor vehicle applications

(57) The bi-dimensional position sensor (1) can be advantageously used in the turn system controlled from the steering wheel of a vehicle and comprises a permanent magnet (3) fixed to a control lever (4) so as to move in a plane along a first (X) and a second (Y) direction and rotate about a third direction (W) orthogonal to the preceding ones. The permanent magnet is movable with respect to an integrated device comprising a first group of sensor elements (10_1-10_3) arranged spaced along the first direction, a second group of sensor elements (10_4-10_7) arranged spaced along the second direction and a third group of sensor elements (10_8-10_9) detecting the angular position of the permanent magnet. Electronics integrated with the sensor elements generate a code associated with each position which the permanent magnet (3) may assume and a control signal (S) corresponding to the desired function.

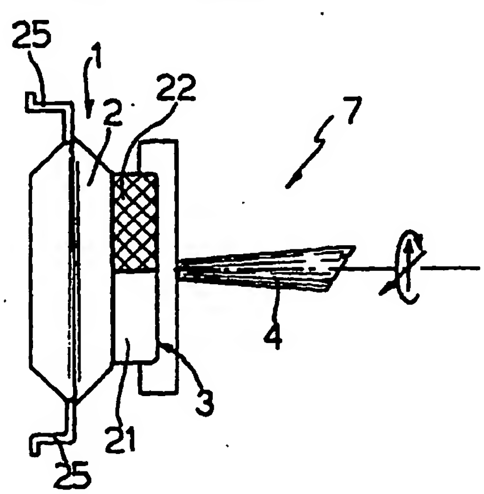

Fig.4

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Description

The invention relates to a bi-dimensional position sensor of magnetic type, particularly for motor vehicle applications, as defined in the pre-characterizing clause of Claim 1.

As is known, at the present time the auxiliary functions controlled on the steering wheel (turn systems), such as switching on the parking lights, full beam, dipped headlights, direction indication, are performed by means of mechanical sliding contacts, the manufacture of which is particularly burdensome and affected by problems associated with the said contacts (wear, ageing etc.).

Control systems for these functions which do not require mechanical sliding contacts are therefore desirable.

In general, this problem is also encountered in all the applications which provide for the sending of a plurality of commands or signals by movement of a control element which acts on sliding contacts and in which there is a large number of operations of the said control element.

The object of the invention is to provide a position sensor which solves the above-mentioned problem.

The invention provides a bi-dimensional position sensor, particularly for motor vehicle applications, as defined in Claim 1.

The invention will now be described with reference to the accompanying drawings which illustrate non-exhaustive embodiments thereof and in which:

Fig. 1 shows the arrangement of sensor elements on a component of this sensor in diagrammatic form;
Fig. 2 shows a transverse section through part of the component of Fig. 1;
Fig. 3 shows a second component of this sensor;
Fig. 4 shows a side view of a control device using this sensor;
Fig. 5 shows a block diagram of a component of this sensor; Figs. 6 and 7 show two diagrams of cooperation between the components of this sensor in diagrammatic form; and
Figs. 8 and 9 show tables relating to codes obtainable for different relative positions of the components of the sensor.

As shown in the accompanying drawings, the sensor 1 comprises an integrated device 2 and a permanent magnet 3 with four quadrants which is movable, with respect to the integrated device 2, parallel to it (in proximity or in contact) so as to move along a plane defined by two different coordinates X and Y and to rotate about an axis Û perpendicular to the plane XY. In its turn the integrated device 2 is formed by a plurality of elements sensitive to magnetic field (sensor elements 10) and by a coding system 11 (Fig. 5).

In a preferred embodiment, shown in Fig. 2 and described below, the sensor elements 10 are formed by Hall effect sensors. Alternatively, as shown diagrammatically in Fig. 5, the sensor elements 10 may be constituted by magneto-resistors produced by means of special magnetic films (such as Co-Fe, Ni-Fe, Ni-Co) having the property of having variable resistance as a function of the magnetic field in which they are placed (see for example R A McCurrie "Ferromagnetic Materials: Structure and Properties", Academic Press, vol. 2, page 93). The magneto-resistors have the advantage of being more sensitive to the magnetic field than Hall effect sensors, but require the deposition on the silicon, by sputtering or by evaporation, of magnetic films not generally used in the microelectronics industry and so they are more expensive to produce.

Fig. 1 shows a possible arrangement of the sensor elements 10 for the detection of 3x4 positions of the permanent magnet 3 in the plane XY and of the rotation by ± 45° about the direction Ω (or, overall, of three different angular positions of the magnet 3). As will be noted, three sensor elements 10_1-10_3 are spaced along a first direction (direction X), four sensor elements 10_4-10_7 are spaced along a second direction (direction Y) perpendicular to the first direction X and two further sensor elements 10_8 and 10_9 are present arranged at a distance from the sensor elements 10_1-10_7 to detect the angle of rotation.

In general, therefore, to detect M positions along the direction X and N positions along the direction Y, at least M + N sensor elements are required, whilst two sensor elements serve to detect rotation in the case of rotations of ± 45° and four sensor elements in the case of rotations of ± 30° with respect to a nominal zero-angle position.

Fig. 2 shows a transverse section of a portion of the silicon slice 12 in which the integrated device 2 is integrated, in correspondence with a Hall effect sensor element 10. In detail, the silicon slice 12 comprises a P-type substrate 13, an N-type epitaxial layer 14 and P^+-type junction insulation regions 15, extending from the surface 16 of the slice 12 to the substrate 13 and surrounding each sensor element 10. A contact region 18 can be seen on the surface 16 of the slice 12, which region, together with a similar contact region which is not shown, is used to supply a current I, whilst contact regions 19, also on the surface 16, enable the potential difference generated by the sensor element 10 to be detected, in a per se known manner. A more complex version of the sensor element 10 which can be advantageously used to produce this sensor 1 is also described in US patent US-A-5,530,345.

As shown in the front view of Fig. 3, the permanent magnet 3 has four quadrants, alternately polarized South (quadrants 21) and North (quadrants 22), defining a centre 24 and of dimensions such that, according to the position assumed by the permanent magnet 3 with respect to the integrated device 2, each of the sen-

sor elements 10 sees a specific quadrant 21, 22 and generates a voltage of corresponding value (positive in the case of North quadrant 22 and negative in the case of South quadrant 21, for example).

As shown in Fig. 4, the sensor 1 may be fitted to a control element, in this case a lever 4, so as to define together therewith a control device 7 which can be controlled manually or by a machine and outputs an electrical control signal which can be used by an actuator. In particular, the permanent magnet 3 is fixed integrally with the lever 4 so as to follow its movements of translation according to the axes X and Y and of rotation about the axis Û. According to a preferred application of the invention the lever 4 is produced as a common control lever fixed to the steering wheel with a joint (not shown) forming a turn system such as to transform the operations of the said lever 4 on the driver's part into the roto-translational movements provided for the permanent magnet 3. In particular, a guide mechanism not shown permits only discrete movements of the permanent magnet 3 with respect to the integrated device 2, as described in greater detail below with reference to Figs. 6 and 7.

As shown in Fig. 5, the voltages generated by the sensor elements 10 are supplied to the coding system 11 comprising a code generator block 27, a processing unit 28 and a memory 29 which stores the association between each code which can be generated by the generator block 27 and a respective control.

In particular, the code generator block 27 receives the analogue voltages generated by each sensor element 10 and transforms them into a digital code of several bits, generating, for example, a logic "1" when it receives a positive voltage (the sensor element 10 detects proximity to a North quadrant 22 of the permanent magnet) and a logic "0" in the opposite case. In practice, the code generator block 27 may be constituted by a battery of comparators each having an input connected to earth and an input receiving the voltage generated by a respective sensor element 10. The binary code thus obtained (which has nine bits in the case of the integrated device with nine sensor elements 10 of Fig. 1) is supplied to the processing unit 28 which, on the basis of the code received and the code stored in the memory 29, determines the corresponding control (switching on parking lights, full beam or dipped headlights or another control) and generates an output signal S supplied, via the pins 25 of the integrated device (Fig. 4), to the relative actuator (not shown) and/or to a central unit of the vehicle (not shown) to be processed.

Obviously, to distinguish the various positions of the permanent magnet 3 with respect to the integrated device 2 it is necessary that each position which the permanent magnet 3 can assume has an unambiguous code which does not coincide with that of any other position or that, in each position, at least one of the sensor elements 10 detects an opposite quadrant 21, 22 with respect to all the other positions. In particular, as regards translation, this requires, for each translation of the permanent magnet 3, that the centre 24 of the permanent magnet 3 is brought to a different side of at least one of the seven sensor elements 10_1-10_7; in the case of the sensor elements 10_1-10_9 of Fig. 1, the centre 24 of the permanent magnet 3 may therefore roughly assume one of the positions shown in Fig. 6 and identified by the letters A-N.

In particular, in Fig. 6, the horizontal and vertical lines are aligned, in each position A-N, with separation lines, denoted by 31, 32, of the quadrants of the permanent magnet 3 and the said permanent magnet 3 has been shown in the position centred on position A; consequently, movements of the permanent magnet 3 with respect to the integrated device 2 such as to bring its centre 24 into correspondence with the positions A-N cause the generation of respective codes, as shown in the table of Fig. 8 for example.

As will be noted, the sensor elements 10_8 and 10_9 are unchanging for every translation in the plane and assume differing values.

Similarly, Fig. 7 shows the position of the permanent magnet 3 with respect to the integrated device 2 when the permanent magnet 3 is centred on position A and rotated by 45° clockwise with respect to Fig. 6. Also shown are the separation lines 31, 32 of the quadrants 21, 22 of the permanent magnet 3 in the different positions A-N of the centre 24; as will be noted, these separation lines 31, 32 are now inclined by ± 45°. In this case, therefore, the code shown in the table of Fig. 9 is obtained.

As will be noted, the sensor elements 10_8 and 10_9 are always associated with a logic "1".

In a manner not shown, in view of the symmetry of the system a rotation of the permanent magnet 3 in the direction opposite to that of Fig. 7 (i.e. 45° anticlockwise with respect to Fig. 6) provides a table complementary to that of Fig. 9.

The sensor described has the following advantages. Primarily it is inexpensive, associated with the manufacturing costs of integrated devices; it is also highly reliable and durable, given that it does not comprise the use of sliding contacts and the magnet 3 may also be at a slight distance from the integrated device 2. Furthermore, it enables the number of controls that can be implemented to be extended with ease and it is not affected by surrounding light conditions.

Finally it will be clear that modifications and variants can be introduced to the sensor described and illustrated here without thereby departing from the protective scope of the invention, as defined in the accompanying claims. In particular, it is emphasized that the electronics for processing the signals generated by the sensor elements 10, or at least part of them, could also not be integrated with the said sensor elements 10 were this to be desirable or appropriate for specific applications.

Claims

1. Bi-dimensional position sensor (1), particularly for motor vehicle applications, comprising a permanent magnet (3) facing and movable with respect to a plurality of elements sensitive to magnetic field (10_1-10_9), characterized in that the said permanent magnet (3) is movable in a plane along a first (X) and a second (Y) direction which are not coincident and is rotatable about a third direction (Ω) orthogonal to the said first and second direction, and in that the said plurality of elements sensitive to magnetic field comprise a first group of sensitive elements (10_1-10_3) arranged spaced along the said first direction, a second group of sensitive elements (10_4-10_7) arranged spaced along the said second direction and a third group of sensitive elements (10_8-10_9) detecting the angular position of the said permanent magnet.

2. Sensor according to Claim 1, characterized in that the said sensitive elements (10_1-10_9) are integrated Hall effect sensors.

3. Sensor according to Claim 1, characterized in that the said sensitive elements (10_1-10_9) are formed by magnetoresistors.

4. Sensor according to one of the preceding Claims, characterized in that the said permanent magnet (3) has four quadrants.

5. Sensor according to one of the preceding Claims, characterized in that the said sensitive elements (10_1-10_9) are integrated in an integrated device (2) also comprising a code generating unit (27), a code memory (29) and a processing unit (28); the said code generating unit (27) being connected to the said sensitive elements and generating a digital code correlated to the output voltage of the said sensitive elements; the said code memory (29) storing a correspondence between a plurality of codes and a respective plurality of controls; and the said processing unit (28) being connected to the said code generating unit and the said processing unit and being suitable for generating control signals (S) corresponding to digital codes received from the said code generating unit according to the said stored correspondence.

6. Control device (7) comprising a control element (4) movable in a plurality of different positions and actuatable to generate a control signal (S) correlated to a respective one of the said plurality of positions, characterized in that it comprises a magnetic sensor (1) according to one of the preceding Claims.

7. Control device according to Claim 6, characterized in that it comprises a control lever (4) of a turn system.

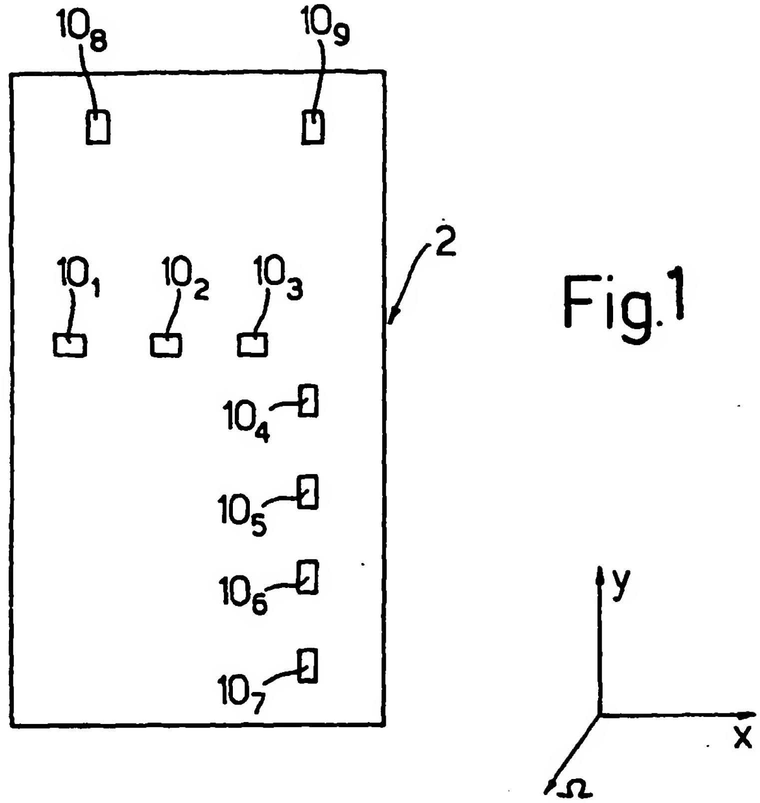
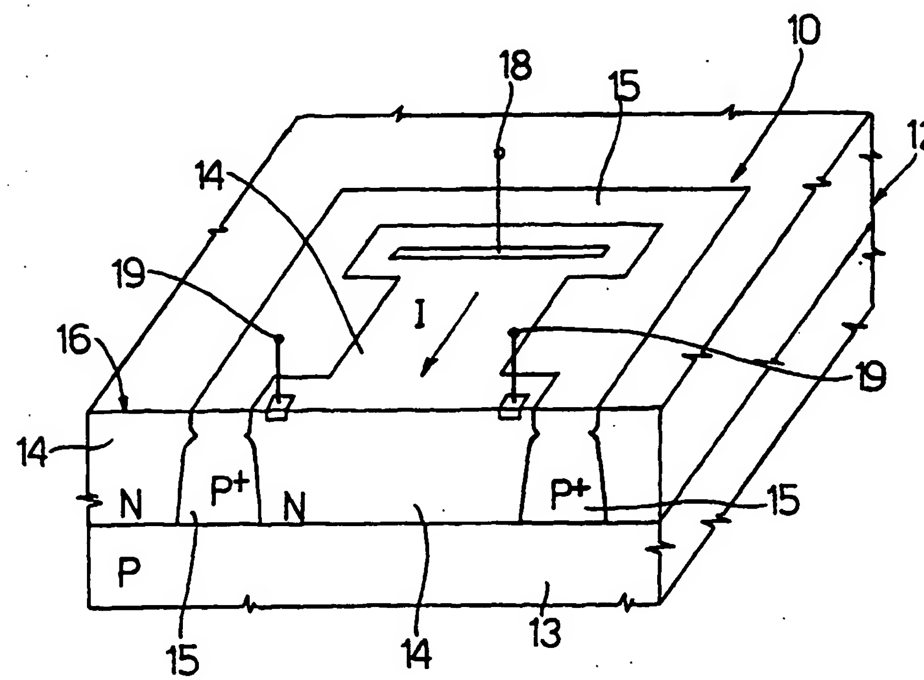

10_8
10_9
2
10_1
10_2
10_3
10_4
10_5
10_6
10_7
y
x
Ω

Fig.1

Fig.2


10
18
15
12
14
19
I
16
19
14
N
P+
N
P+
15
P
15
14
13

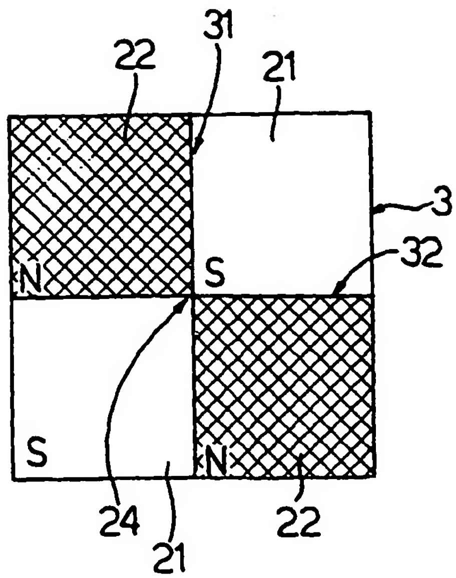


Fig.3

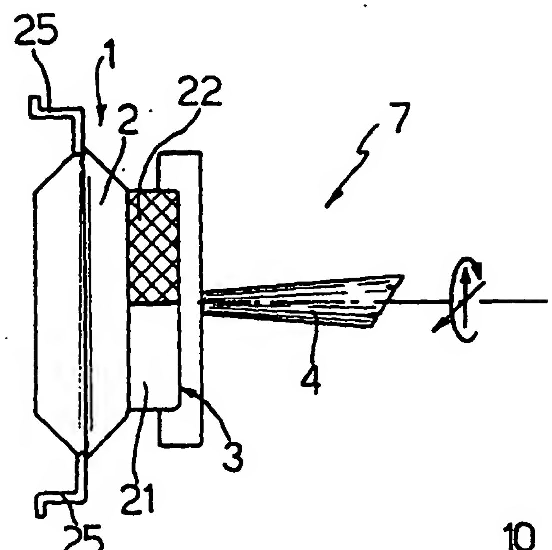


Fig.4

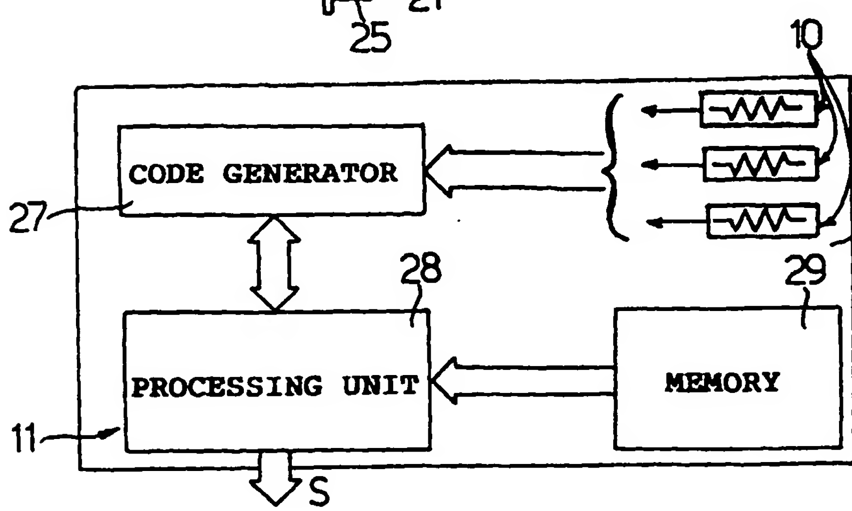


Fig.5

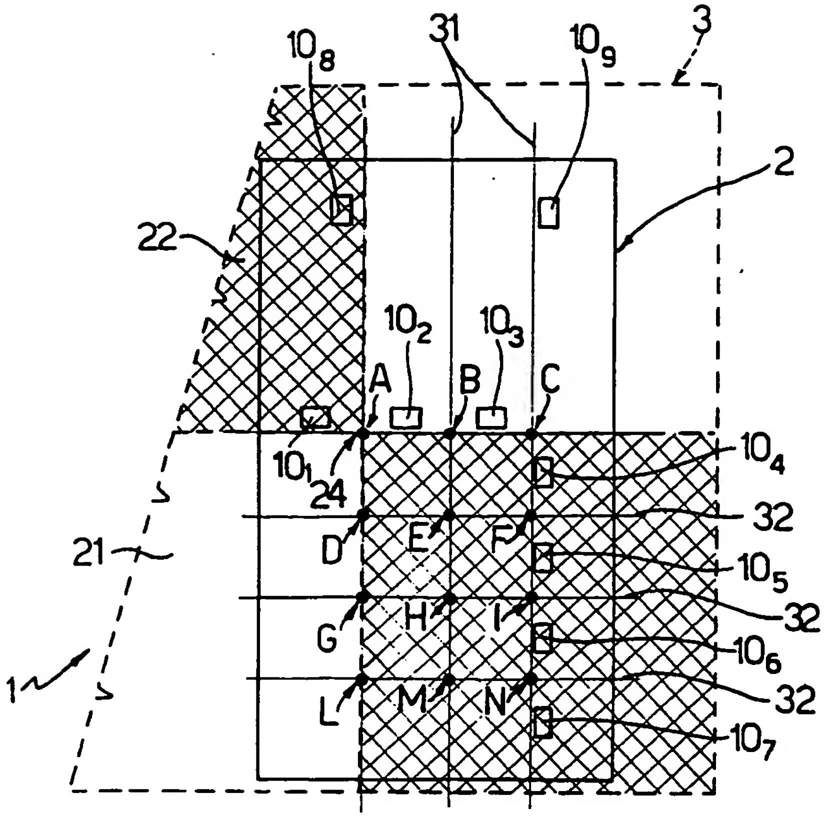

3
31
10_8
10_9
2
22
10_2
10_3
A
B
C
10_1
24
10_4
32
D
E
F
21
10_5
G
H
I
32
10_6
1
L
M
N
32
10_7

Fig. 6

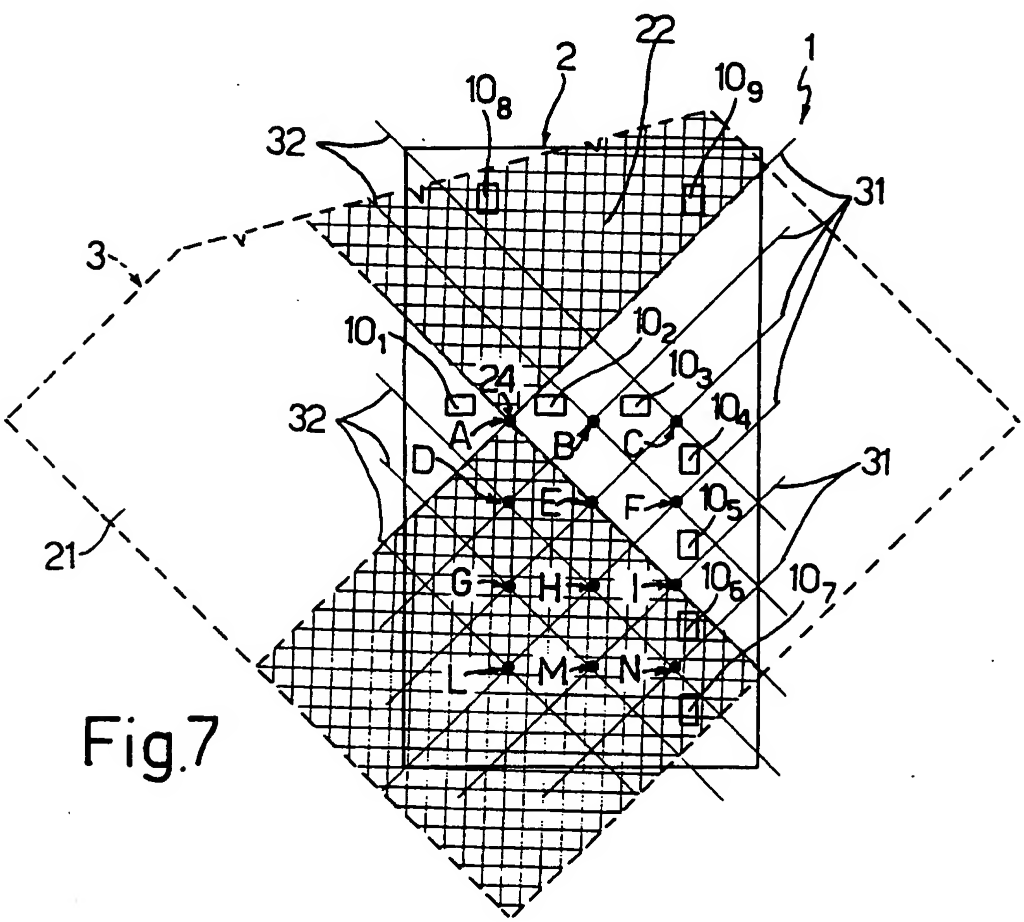

22
2
1
10_8
10_9
32
31
3
10_1
10_2
24
10_3
10_4
32
A
B
C
D
E
F
10_5
31
21
G
H
I
10_6
10_7
L
M
N

Fig.7

	10_1	10_2	10_3	10_4	10_5	10_6	10_7	10_8	10_9
A	1	0	0	1	1	1	1	1	0
B	1	1	0	1	1	1	1	1	0
C	1	1	1	1	1	1	1	1	0
D	1	0	0	0	1	1	1	1	0
E	1	1	0	0	1	1	1	1	0
F	1	1	1	0	1	1	1	1	0
G	1	0	0	0	0	1	1	1	0
H	1	1	0	0	0	1	1	1	0
I	1	1	1	1	1	1	1	1	0
L	1	0	0	0	0	0	1	1	0
M	1	1	0	0	0	0	1	1	0
N	1	1	1	0	0	0	1	1	0

Fig. 8

	10_1	10_2	10_3	10_4	10_5	10_6	10_7	10_8	10_9
A	0	0	0	0	0	1	1	1	1
B	0	0	0	0	1	1	1	1	1
C	0	0	0	1	1	1	1	1	1
D	1	1	0	0	0	0	1	1	1
E	0	1	1	0	0	1	1	1	1
F	0	0	1	1	1	1	1	1	1
G	1	1	1	0	0	0	0	1	1
H	1	1	1	1	0	0	1	1	1
I	0	1	1	1	1	1	1	1	1
L	1	1	1	1	0	0	0	1	1
M	1	1	1	1	1	0	0	1	1
N	1	1	1	1	1	1	1	1	1

Fig. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 98 10 9368

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X A	US 4 459 578 A (SAVA ROBERT J ET AL) 10 July 1984 * abstract; figures 1,5 * * column 1, line 52 - column 2, line 36 * ---	1,2,6 4,5	G01D5/14 G01V3/08
X	US 5 450 054 A (SCHMERSAL LARRY J) 12 September 1995 * abstract; figures 1-4 * * column 1, line 52 - column 2, line 3 * * column 3, line 49 - column 4, line 3 * * column 6, line 5 - column 7, line 25 * ---	1,2,5,6,8	
X	US 4 500 867 A (ISHITOBI YOSHIMITSU ET AL) 19 February 1985 * abstract; figure 11 * ---	1,3	
A	EP 0 501 906 A (HARDI INT AS) 2 September 1992 * abstract; figures 1,3,6 * * column 2, line 26 - column 3, line 4 * * column 5, line 3 - line 12 * ---	1,2,6	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	US 4 574 286 A (ANDRESEN HERMAN J) 4 March 1986 * abstract * ---	4	G01D G01V G06K
A	US 4 458 226 A (CHO CHIH M) 3 July 1984 * abstract; figure 1 * * column 2, line 39 - line 47 * -----	4	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	31 August 1998	Anderson, A

CATEGORY OF CITED DOCUMENTS

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